

## COLORED DATA STORAGE MEDIA

## CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of the filing date of U.S. Provisional Application Serial No. 60/166,135, filed on September 29, 2000, which is hereby incorporated by reference.

## TECHNICAL FIELD

[0002] The present disclosure relates to data storage media, and especially relates to fluorescent, plastic data storage media.

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## BACKGROUND

[0003] Optical, magnetic and magneto-optic media are primary sources of high performance storage technology which enables high storage capacity coupled with a reasonable price per megabyte of storage. Use of optical media has become widespread in audio, video, and computer data applications in such formats as compact disk (CD), digital versatile disk (DVD) including multi-layer structures like DVD-5, DVD-9, and multi-sided formats such as DVD-10, and DVD-18, magneto-optical disk (MO), and other write-once and rewritable formats such as CD-R, CD-RW, DVD-R, DVD-RW, DVD+RW, DVD-RAM. In these and other formats, data are encoded onto a substrate into a digital data series. In pre-recorded media, such as CD, the data are typically pits and grooves formed on the surface of a plastic substrate through a method such as injection molding, stamping or the like.

[0004] In recordable and rewritable media, the data are encoded by laser, which illuminates an active data layer that undergoes a phase change, thus producing a series of highly-reflecting or non-reflective regions making up the data stream. In these formats, a laser beam first travels through a plastic substrate before reaching the data layer. At the data layer, the beam is either reflected or not, in accordance with the

endcoded data. The laser light then travels back through the plastic and into an optical detector system where the data are interpreted.

[0005] It is well known in the art that, due to the sensitivity of the optical readout system, the amount of absorption of the light by the media should be

5 minimized. Consequently, the plastic in the optical media is a colorless, transparent material having good birefringence properties, such as polycarbonate. Although media formats have been introduced which read data from the top-side of a substrate, the vast majority of playback systems are only compatible with media requiring the laser to travel through the substrate twice. Hence, the transparency to the laser is a  
10 requirement and colorless materials are typically used to maximize transparency at the laser wavelength.

[0006] The widespread use of colorless, transparent materials makes product differentiation difficult, except by costly printing methods on the top surface of the optical media. Furthermore, in the cases where printed decorations cover one entire  
15 surface of a disk, the covered surface is unusable for data storage.

[0007] What is needed in the art are colored plastic compositions for use as optical media.

#### BRIEF SUMMARY

[0008] The colored data storage media overcomes the above described drawbacks and deficiencies. In one embodiment, the media comprises: a substrate  
20 comprising colorant and plastic, wherein the substrate has a transmissivity of less than about 85% at a readback laser wavelength, when traversing a 1.2 mm thick colored substrate (disk).

[0009] In another embodiment, the media, comprises: a substrate comprising a  
25 fluorescent colorant and plastic, wherein the substrate has a fluorescent color emission wavelength which is not equal to the readback laser wavelength.

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## DETAILED DESCRIPTION

[0010] The present invention relates to data storage media, namely, colored optical data storage media and methods for making the same. In one embodiment, the colored media has, at the readback laser wavelength, a transmissivity of light of about 5 85% or less, with about 70% to about 85% preferred, about 75% to about 80% also preferred, and about 75% to about 85% especially preferred, when traversing a 1.2 mm thick colored substrate (disk). Alternatively, if fluorescent, the media preferably emits light at a wavelength which does not inhibit data retrieval. The fluorescent media can comprise a substrate which has a transmissivity, at the readback laser 10 wavelength, exceeding 68%, with about 70% to about 95% preferred, about 70% to about 95% more preferred, and about 70% to about 85% especially preferred, when traversing a 1.2 mm thick substrate (disk).

[0011] Typically, these storage media can comprise a substrate comprising a plastic and a colorant which does not inhibit data retrieval. Generally, up to about 10 15 weight percent (wt%) colorant can be used, with up to about 5 wt% preferred, up to about 1 wt% colorant more preferred, and less than about 0.5 wt% or so colorant especially preferred, based upon the total weight of the substrate.

[0012] In theory, any plastic that exhibits appropriate properties and can be employed. However, the plastic should be capable of withstanding the subsequent 20 processing parameters (e.g., application of subsequent layers) such as sputtering (i.e., temperatures up to and exceeding about 200°C (typically up to or exceeding about 300°C) for magnetic media, and temperatures of about room temperature (about 25°C) up to about 150°C for magneto-optic media). That is, it is desirable for the plastic to have sufficient thermal stability to prevent deformation during the deposition steps. 25 For magnetic media, appropriate plastics include thermoplastics with glass transition temperatures greater than about 150°C, with greater than about 200°C preferred (e.g., polyetherimides, polyetheretherketones, polysulfones, polyethersulfones, polyetherethersulfones, polyphenylene ethers, polyimides, high heat polycarbonates, etc.); with materials having glass transition temperatures greater than about 250°C

more preferred, such as polyetherimide in which sulfonedianiline or oxydianiline has been substituted for m-phenylenediamine, among others, as well as polyimides, such as Probimide (or the dry powder equivalent, Matrimid 5218, from Ciba Geigy Chemical); combinations comprising at least one of the foregoing plastics, and others.

5 [0013] Additionally, it is possible for thermosets to be used in the application provided the thermoset possess sufficient flow under the stamping conditions to permit formation of the desired surface features. As various applications may require polymers with different glass transition temperatures, it may be advantageous to be able to adjust the glass transition temperature of a plastic (homopolymer, copolymer, 10 or blend) to achieve a film with the desired glass transition temperature. To this end, polymer blends, such as those described in U.S. Patent No. 5,534,602 (to Lupinski and Cole, 1996), may be employed in the preparation of the coating solution. In this example, polymer blends provide, selectively, variable glass transition temperatures of about 190°C to about 320°C.

15 [0014] Some possible examples of plastics include, but are not limited to, amorphous, crystalline and semi-crystalline thermoplastic materials: polyvinyl chloride, polyolefins (including, but not limited to, linear and cyclic polyolefins and including polyethylene, chlorinated polyethylene, polypropylene, and the like), polyesters (including, but not limited to, polyethylene terephthalate, polybutylene 20 terephthalate, polycyclohexylmethylene terephthalate, and the like), polyamides, polysulfones (including, but not limited to, hydrogenated polysulfones, and the like), polyimides, polyether imides, polyether sulfones, polyphenylene sulfides, polyether ketones, polyether ether ketones, ABS resins, polystyrenes (including, but not limited to, hydrogenated polystyrenes, syndiotactic and atactic polystyrenes, polycyclohexyl 25 ethylene, styrene-co-acrylonitrile, styrene-co-maleic anhydride, and the like), polybutadiene, polyacrylates (including, but not limited to, polymethylmethacrylate, methyl methacrylate-polyimide copolymers, and the like), polyacrylonitrile, polyacetals, polycarbonates, polyphenylene ethers (including, but not limited to, those derived from 2,6-dimethylphenol and copolymers with 2,3,6-trimethylphenol, and the 30 like), ethylene-vinyl acetate copolymers, polyvinyl acetate, liquid crystal polymers,

ethylene-tetrafluoroethylene copolymer, aromatic polyesters, polyvinyl fluoride, polyvinylidene fluoride, polyvinylidene chloride, Teflons, as well as thermosetting resins such as epoxy, phenolic, alkyds, polyester, polyimide, polyurethane, mineral filled silicone, bis-maleimides, cyanate esters, vinyl, and benzocyclobutene resins, in addition

5 to blends, copolymers, mixtures, reaction products and composites comprising at least one of the foregoing plastics.

[0015] As used herein, the terms "polycarbonate", "polycarbonate composition", and "composition comprising aromatic carbonate chain units" includes compositions having structural units of the formula (I):



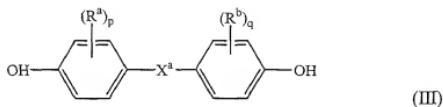
10 [0016] in which at least about 60 percent of the total number of  $\text{R}^1$  groups are aromatic organic radicals and the balance thereof are aliphatic, alicyclic, or aromatic radicals. Preferably,  $\text{R}^1$  is an aromatic organic radical and, more preferably, a radical of the formula (II):



[0017] wherein each of  $\text{A}^1$  and  $\text{A}^2$  is a monocyclic divalent aryl radical and  $\text{Y}^1$  15 is a bridging radical having one or two atoms which separate  $\text{A}^1$  from  $\text{A}^2$ . In an exemplary embodiment, one atom separates  $\text{A}^1$  from  $\text{A}^2$ . Illustrative, non-limiting examples of radicals of this type are  $\text{-O-}$ ,  $\text{-S-}$ ,  $\text{-S(O)-}$ ,  $\text{-S(O}_2\text{-)}$ ,  $\text{-C(O)-}$ , methylene, cyclohexyl-methylene, 2-[2,2,1]-bicycloheptylidene, ethylidene, isopropylidene, neopentylidene, cyclohexylidene, cyclopentadecylidene, cyclododecylidene, and 20 adamantlylidene. The bridging radical  $\text{Y}^1$  can be a hydrocarbon group or a saturated hydrocarbon group such as methylene, cyclohexylidene or isopropylidene.

[0018] Polycarbonates can be produced by the interfacial reaction of dihydroxy compounds in which only one atom separates  $\text{A}^1$  and  $\text{A}^2$ . As used herein,

the term "dihydroxy compound" includes, for example, bisphenol compounds having general formula (III) as follows:



[0019] wherein  $\text{R}^{\text{a}}$  and  $\text{R}^{\text{b}}$  each represent a halogen atom or a monovalent hydrocarbon group and may be the same or different;  $\text{p}$  and  $\text{q}$  are each independently integers from 0 to 4; and  $\text{X}^{\text{a}}$  represents one of the groups of formula (IV):



[0020] wherein  $\text{R}^{\text{c}}$  and  $\text{R}^{\text{d}}$  each independently represent a hydrogen atom or a monovalent linear or cyclic hydrocarbon group and  $\text{R}^{\text{e}}$  is a divalent hydrocarbon group.

[0021] Some illustrative, non-limiting examples of suitable dihydroxy compounds include dihydric phenols and the dihydroxy-substituted aromatic hydrocarbons disclosed by name or formula (generic or specific) in U.S. Patent 4,217,438, which is incorporated herein by reference. A nonexclusive list of specific examples of the types of bisphenol compounds that may be represented by formula (III) includes the following: 1,1-bis(4-hydroxyphenyl) methane; 1,1-bis(4-hydroxyphenyl) ethane; 2,2-bis(4-hydroxyphenyl) propane (hereinafter "bisphenol A" or "BPA"); 2,2-bis(4-hydroxyphenyl) butane; 2,2-bis(4-hydroxyphenyl) octane; 1,1-bis(4-hydroxyphenyl) propane; 1,1-bis(4-hydroxyphenyl) n-butane; bis(4-hydroxyphenyl) phenylmethane; 2,2-bis(4-hydroxy-1-methylphenyl) propane; 1,1-bis(4-hydroxy-t-butylphenyl) propane; bis(hydroxyaryl) alkanes such as 2,2-bis(4-hydroxy-3-bromophenyl) propane; 1,1-bis(4-hydroxyphenyl) cyclopentane; and bis(hydroxyaryl) cycloalkanes such as 1,1-bis(4-hydroxyphenyl) cyclohexane; and the like as well as combinations comprising at least one of the foregoing.

[0022] It is also possible to employ polycarbonates resulting from the polymerization of two or more different dihydric phenols or a copolymer of a dihydric phenol with a glycol or with a hydroxy- or acid-terminated polyester or with a dibasic acid or with a hydroxy acid or with an aliphatic diacid in the event a carbonate

5 copolymer rather than a homopolymer is desired for use. Generally, useful aliphatic diacids have from 2 to about 40 carbons. A preferred aliphatic diacid is dodecanoic acid. Polyarylates and polyester-carbonate resins or their blends can also be employed. Branched polycarbonates are also useful, as well as blends of linear polycarbonate and a branched polycarbonate. The branched polycarbonates may be  
10 prepared by adding a branching agent during polymerization.

[0023] These branching agents are well known and may comprise polyfunctional organic compounds containing at least three functional groups which may be hydroxyl, carboxyl, carboxylic anhydride, haloformyl and mixtures comprising at least one of the foregoing. Specific examples include trimellitic acid,

15 trimellitic anhydride, trimellitic trichloride, tris-p-hydroxy phenyl ethane, isatin-bis-phenol, tris-phenol TC (1,3,5-tris((p-hydroxyphenyl)isopropyl)benzene), tris-phenol PA (4(4(1,1-bis(p-hydroxyphenyl)-ethyl) alpha,alpha-dimethyl benzyl)phenol), 4-chloroformyl phthalic anhydride, trimesic acid and benzophenone tetracarboxylic acid, and the like. The branching agents may be added at a level of about 0.05 to  
20 about 2.0 weight percent. Branching agents and procedures for making branched polycarbonates are described in U.S. Patent. Nos. 3,635,895 and 4,001,184 which are incorporated by reference. All types of polycarbonate end groups are herein contemplated.

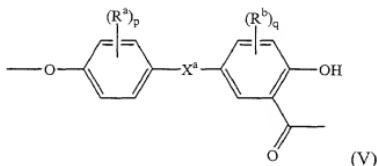
[0024] Preferred polycarbonates are based on bisphenol A, in which each of

25  $A^1$  and  $A^2$  is p-phenylene and  $Y^1$  is isopropylidene. Preferably, the weight average molecular weight of the polycarbonate is about 5,000 to about 100,000, more preferably about 10,000 to about 65,000, and most preferably about 15,000 to about 35,000.

[0025] In monitoring and evaluating polycarbonate synthesis, it is of particular interest to determine the concentration of Fries product present in the polycarbonate.

As noted, the generation of significant Fries product can lead to polymer branching, resulting in uncontrollable melt behavior. As used herein, the terms “Fries” and

5 “Fries product” denote a repeating unit in polycarbonate having the formula (V):



[0026] wherein  $X^a$  is a bivalent radical as described in connection with Formula (III) *supra*.

[0027] The polycarbonate composition may also include various additives ordinarily incorporated in resin compositions of this type. Such additives are, for

10 example, fillers or reinforcing agents; heat stabilizers; antioxidants; light stabilizers; plasticizers; antistatic agents; mold releasing agents; additional resins; blowing agents; and the like, as well as combinations comprising at least one of the foregoing additives. Examples of fillers or reinforcing agents include glass fibers, asbestos,

carbon fibers, silica, talc and calcium carbonate. Examples of heat stabilizers include triphenyl phosphite, tris-(2,6-dimethylphenyl)phosphite, tris-(mixed mono-and di-

15 nonylphenyl)phosphite, dimethylbenene phosphonate and trimethyl phosphate.

Examples of antioxidants include octadecyl-3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate, and pentaerythritol-tetrakis[3-(3,5-di-tert-butyl-4-

20 hydroxyphenyl)propionate]. Examples of light stabilizers include 2-(2-hydroxy-5-

methyl[phenyl]benzotriazole, 2-(2-hydroxy-5-tert-octyl[phenyl])-benzotriazole and 2-hydroxy-4-n-octoxy benzophenone. Examples of plasticizers include dioctyl-4,5-epoxy-hexahydrophthalate, tris-(octoxycarbonylethyl)isocyanurate, tristearin and epoxidized soybean oil. Examples of the antistatic agent include glycerol monostearate, sodium stearyl sulfonate, and sodium dodecylbenzenesulfonate.

Examples of mold releasing agents include stearyl stearate, beeswax, montan wax and paraffin wax. Examples of other resins include but are not limited to polypropylene, polystyrene, polymethyl methacrylate, and polyphenylene oxide. Combinations of any of the foregoing additives may be used. Such additives may be mixed at a suitable

5 time during the mixing of the components for forming the composition.

[0028] The color is imparted to the substrate with a colorant (e.g., dye, pigment, or the like). The amount and type of colorant is chosen to avoid producing a substrate having contaminants (i.e., by-products) which produce data readout errors, and to attain the desired color, while controlling transmissivity, at the readback laser

10 wavelength, to greater than about 68%, when traversing a 1.2 mm thick colored substrate (disk). Contrary to conventional belief, the substrate may be fluorescent, that is, emit light at a particular wavelength. In this embodiment, the colorant is a fluorescent material which has a fluorescent color emission wavelength which is not equal to the readback laser wavelength, and preferably different by at least about 10

15 nanometers (nm) (i.e., higher or lower) than the readback laser wavelength, with a difference of about 15 nm or greater preferred, and about 20 nm or greater especially preferred. Here it is further preferred that the substrate have a transmissivity at the readback laser frequency, of greater than about 70% when traversing a 1.2 mm thick colored substrate (disk).

20 [0029] Some possible fluorescent colorants include:

| DESCRIPTION            | COMPOSITION   |
|------------------------|---|
| C.I. Pigment Red 181   | benzothiophenone ( $C_{18}H_{10}Cl_2O_2S_2$ )                         |
| C.I. Solvent Orange 63 | 14H-antra{2.1.9-MNA}thioxanthan-14-one                                |
| C.I. Disperse Red 364  | 2(3oxobenzothien2 (3H) yliden) benzothiophenone                       |
| C.I. Solvent Blue 97   | anthraquinone 1,4-bis(2,6-diethyl-4-methylphenyl) aminoanthracendione |
| C.I. Solvent Green 5   | 3,9-perylendicarboxlic acid, bis-2-methylpropyl ester                 |
| C.I. Solvent Yellow 98 | 2-octadecylthioxanthenoiso quinolinfonr                               |

as well as other fluorescent colorants, and combinations comprising at least one of the foregoing colorants.

[0030] Further color or design may be imparted to the substrate via a decorative layer which does not comprise an absorption percentage limitation. The 5 decorative layer, which is disposed on a side of the disk opposite a data storage layer or in between data storage layers which are read from opposite sides of the disk, can be any color or design, such as a design which optionally includes sparkle, i.e., visual effects which scatter the incident light (such as glass or metal (in the form of flakes, chips, particles, powder, and the like, as well as combinations comprising at least one 10 of the foregoing forms, with flakes preferred), titanium dioxide ( $TiO_2$ ), mica, fiberglass, angular metameric materials such as, ChromaFlair Gold/Silver 080, ChromaFlair Cyan/Purple 230 (commercially available from Flex Products, Santa Rosa, California), among other materials, as well as combinations comprising at least one of the foregoing visual effects.

15 [0031] In addition to the plastic and colorant, the composition may optionally include various additives ordinarily incorporated in resin compositions of this type. Such additives may include antioxidants, heat stabilizers, anti-static agents (tetra alkylammonium benzene sulfonate salts, tetra alkylphosphonium benzene sulfonate salts, and the like), mold releasing agents (pentaerythritol tetrastearate; glycerol 20 monostearate, and the like), and the like, and combinations comprising at least one of the foregoing. For example, the substrate can comprise about 0.01 to about 0.1 wt% of a heat stabilizer; about 0.01 to about 0.2 wt% of an antistatic agent; and about 0.1 to about 1 wt% of a mold releasing agent; based upon the total weight of the substrate.

25 [0032] Some possible antioxidants include, for example, organophosphites, e.g., tris(nonyl-phenyl)phosphite, tris(2,4-di-t-butylphenyl)phosphite, bis(2,4-di-t-butylphenyl)pentaerythritol diphosphite, distearyl pentaerythritol diphosphite and the like; alkylated monophenols, polyphenols and alkylated reaction products of polyphenols with dienes, such as, for example, tetrakis[methylene(3,5-di-tert-butyl-4-hydroxyhydrocinnamate)] methane, 3,5-di-tert-butyl-4-hydroxyhydrocinnamate

octadecyl, 2,4-di-tert-butylphenyl phosphite, and the like; butylated reaction products of para-cresol and dicyclopentadiene; alkylated hydroquinones; hydroxylated thiadiphenyl ethers; alkylidene-bisphenols; benzyl compounds; esters of beta-(3,5-di-tert-butyl-4-hydroxyphenyl)-propionic acid with monohydric or polyhydric alcohols;

5 esters of beta-(5-tert-butyl-4-hydroxy-3-methylphenyl)-propionic acid with monohydric or polyhydric alcohols; esters of thioalkyl or thioaryl compounds, such as, for example, distearylthiopropionate, dilaurylthiopropionate, ditridecylthiopropionate, and the like; amides of beta-(3,5-di-tert-butyl-4-hydroxyphenyl)-propionic acid; and the like, as well as combinations comprising at 10 least one of the foregoing.

[0033] Other potential additives which may be employed comprise: UV absorbers; stabilizers such as light and thermal stabilizers (e.g., acidic phosphorous-based compounds); hindered phenols; zinc oxide and/or zinc sulfide particles; lubricants (mineral oil, and the like), plasticizers, dyes (quinines, azobenzenes, and the like); among others, as well as combinations comprising at least one of the foregoing additives.

[0034] In order to aide in the processing of the plastic, particularly polycarbonate, catalyst(s) may also be employed, namely in the extruder or other mixing device. The catalyst typically assists in controlling the viscosity of the 20 resulting material. Possible catalysts include tetraalkylammonium hydroxide, tetraalkylphosphonium hydroxide and the like, with diethyldimethylammonium hydroxide and tetrabutylphosphonium hydroxide preferred. The catalyst(s) can be employed alone or in combination with quenchers such as acids, such as phosphoric acid, and the like. Additionally, water may be injected into the polymer melt during 25 compounding and removed as water vapor through a vent to remove residual volatile compounds.

[0035] Data storage media can be produced by first forming the plastic using a conventional reaction vessel capable of adequately mixing various precursors, such as a single or twin screw extruder, kneader, blender, or the like. The precursors can

either be premixed with the colorant (e.g., in a pellet, powder, and/or liquid form) and simultaneously fed through a hopper into the extruder, or the colorant can be optionally added in the feed throat or through an alternate injection port of the injection molding machine or other molding.

5 [0036] The extruder should be maintained at a sufficiently high temperature to melt the plastic precursors without causing decomposition thereof. For polycarbonate, for example, temperatures of about 220°C to about 360°C can be used, with about 260°C to about 320°C preferred. Similarly, the residence time in the extruder should be controlled to minimize decomposition. Residence times of up to about 2 minutes

10 (min) or more can be employed, with up to about 1.5 min preferred, and up to about 1 min especially preferred. Prior to extrusion into the desired form (typically pellets, sheet, web, or the like, the mixture can optionally be filtered, such as by melt filtering and/or the use of a screen pack, or the like, to remove undesirable contaminants or decomposition products.

15 [0037] Once the plastic composition has been produced, it can be formed into the data storage media using various molding and/or processing techniques. Possible molding techniques include injection molding, film casting, extrusion, press molding, blow molding, stamping, and the like. Once the substrate has been produced, additional processing, such as electroplating, coating techniques (spin coating, spray

20 coating, vapor deposition, screen printing, painting, dipping, and the like), lamination, sputtering, and combinations comprising at least one of the foregoing processing techniques, among others conventionally known in the art, may be employed to dispose desired layers on the colored substrate.

[0038] An example of a polycarbonate data storage media comprises an injection molded colored polycarbonate substrate which may optionally comprise a hollow (bubbles, cavity, and the like) or filled (metal, plastics, glass, ceramic, and the like, in various forms such as fibers, spheres, particles, and the like) core. Disposed on the substrate are various layers including: a data layer, dielectric layer(s), a reflective layer(s), and/or a protective layer, as well as combinations comprising at

least one of the foregoing layers. These layers comprise conventional materials and are disposed in accordance with the type of media produced. For example, for a first surface media, the layers may be protective layer, dielectric layer, data storage layer, dielectric layer, and then the reflective layer disposed in contact with the substrate,

5 with an optional decorative layer disposed on the opposite side of the substrate.

Meanwhile, for an optical media, the layers may be optional decorative layer, protective layer, reflective layer, dielectric layer, and data storage layer, with a subsequent dielectric layer in contact with the substrate. It is understood that the form of the media is not limited to disk-shape, but may be any shape which can be

10 accommodated in a readout device.

[0039] The data storage layer(s) may comprise any material capable of storing retrievable data, such as an optical layer, magnetic layer, or a magneto-optic layer.

Typically the data layer has a thickness of up to about 600 Angstroms (Å) or so, with a thickness up to about 300Å preferred. Possible data storage layers include, but are

15 not limited to, oxides (such as silicone oxide), rare earth element – transition metal alloy, nickel, cobalt, chromium, tantalum, platinum, terbium, gadolinium, iron, boron, others, and alloys and combinations comprising at least one of the foregoing, organic dye (e.g., cyanine or phthalocyanine type dyes), and inorganic phase change compounds (e.g., TeSeSn, InAgSb, and the like).

20 [0040] The protective layer(s), which protect against dust, oils, and other contaminants, can have a thickness of greater than about 100 microns ( $\mu$ ) to less than about 10Å, with a thickness of about 300Å or less preferred in some embodiments, and a thickness of about 100Å or less especially preferred. The thickness of the protective layer(s) is usually determined, at least in part, by the type of read/write

25 mechanism employed, e.g., magnetic, optic, or magneto-optic. Possible protective layers include anti-corrosive materials such as gold, silver, nitrides (e.g., silicon nitrides and aluminum nitrides, among others), carbides (e.g., silicon carbide and others), oxides (e.g., silicon dioxide and others), polymeric materials (e.g., polyacrylates or polycarbonates), carbon film (diamond, diamond-like carbon, and the like), among others, and combinations comprising at least one of the foregoing.

[0041] The dielectric layer(s), which are disposed on one or both sides of the data storage layer and are often employed as heat controllers, can typically have a thickness of up to or exceeding about 1,000Å and as low as about 200Å or less.

Possible dielectric layers include nitrides (e.g., silicon nitride, aluminum nitride, and others); oxides (e.g., aluminum oxide); carbides (e.g., silicon carbide); and combinations comprising at least one of the foregoing materials, among other materials compatible within the environment and preferably not reactive with the surrounding layers.

[0042] The reflective layer(s) should have a sufficient thickness to reflect a sufficient amount of energy (e.g., light) to enable data retrieval. Typically the reflective layer(s) can have a thickness of up to about 700Å or so, with a thickness of about 300Å to about 600Å generally preferred. Possible reflective layers include any material capable of reflecting the particular energy field, including metals (e.g., aluminum, silver, gold, titanium, and alloys and mixtures comprising at least one of the foregoing metals, and others).

[0043] In addition to the data storage layer(s), dielectric layer(s), protective layer(s) and reflective layer(s), other layers can be employed such as lubrication layer and others. Useful lubricants include fluoro compounds, especially fluoro oils and greases, and the like.

[0044] The following examples are provided to further illustrate the present invention and not to limit the scope hereof.

## EXAMPLES

[0045] Colored pellets were prepared by mixing low viscosity polycarbonate resin powder (melt flow at 250°C of 11 grams per 10 minutes (ASTM-D1238); molecular weight of about 17,700 grams per mole (g/mol) measured on GPC) with colorants specified in the Table. Formulations also included mold release agent (0.02 wt% glycerol monostearate) and Doverphos (S-9228); Bis(2,4-dicumylphenyl)pentaerythritol diphosphate antioxidant at 0.02 wt%). The blends

were melted in a 30 millimeter (mm) twin-screw extruder, passed through a die, cooled, and pelletized.

[0046] Resulting pellets were injection molded into 1.2 mm thick compact disk substrates using a Krauss Maffei 80/190°C Marathon Series, CD Liner, w/Non-

5 Open Mold. Processing conditions as follows: Barrel Zone Temperature of about 250 to about 330°C; Mold Temperatures set to 45°C; Injection Speed Profile of about 20 millimeters per second (mm/s) to about 65 mm/s, 4 stages; Holding Pressure profile of about 150 bar to about 550 bar, 5 stages; Holding Pressure Time of about 0.05 to about 0.25 seconds, 5 stages; Cooling Time set for 2.5 seconds; Clamp Tonnage set 10 for 400 kN; Injection pressure set at 1795 bar; Injection Position Profile of about 17.0 mm to about 4.5 mm, 4 stages. The resulting disks were tested for Block Error Rate on a CD Associates SL100 optical tester. Block Error Rate (BLER) is a measure of the number of blocks of data that have at least one occurrence of erroneous data. BLER is the combination of E11+E21+E31+E12+E22+E32 errors. A Block Error 15 Rate below about 220 pulses is typically required in industry, with below 100 preferred, and below 50 especially preferred.

[0047] Pellets were also injection molded into 1.2 mm thick colored substrate (disk) and placed in spectrophotometer to determine the absorbance at 780 nanometers (nm), (i.e., the wavelength of the optical disk tester. If the disc is not readable by the 20 tester an error message is given such as: “Unable to Retrieve VTOC (1FB)”. Which means that the tester could not establish the “Volume Table of Contents”, this information shows the layout of the program material on the disc.

| TABLE                    |  |  |                |             |      |
|--------------------------|--|--|----------------|-------------|------|
| Color                    | Colorant   | Loading (wt%)                            | % TRM at 780nm | Elect. Test | BLER |
| Clear                    | --   | --                                       | 95.0           | Pass        | 6.2  |
| lt. Orange fluorescent   | R672: CI Solvent Orange 63   | 0.005                                    | 94.8           | Pass        | 15.4 |
| dk. Orange fluorescent   | R65: C.I. Pigment Red 181  | 0.005                                    | 94.7           | Pass        | 9.5  |
| Magenta fluorescent      | R663: Kenawax Fluorescent Red 3BYP   | 0.050                                    | 94.7           | pass        | 38.5 |
| Brightened lt. Blue      | R73: C.I. Solvent Blue 97 R513: 2.5bis(5'-tert-butyl-2-benzoxazolyl) thiophene   | 0.0003<br>0.008                          | 94.4           | Pass        | 25.6 |
| green/yellow fluorescent | R887: C.I. Solvent Green   | 0.100                                    | 94.6           | Pass        | 13.7 |
| Brightened lt. Green     | R882: C.I. Solvent Yellow 98R73: C.I. Solvent Blue 97  | 0.00007<br>0.0004                        | 94.7           | Pass        | 31.2 |
| green purple             | AM190: ChromaFlair Green/Purple 190  | 0.110                                    | 67.9           | fail        |      |
| gold silver              | AM080: ChromaFlair Gold/Silver 080   | 0.060                                    | 65.8           | fail        |      |
| cyan purple              | AM230: ChromaFlair Cyan/Purple 230   | 0.100                                    | 65.3           | fail        |      |
| Sandorin blue            | R7260: Pigment Blue 60   | 0.010                                    | 71.1           | pass        | 64.1 |
| Pink with glass flake    | R666: C.I. Solvent Red 207 R203: Carbon Black Monarch 800 R71: C.I. Solvent Violet 13 R0979: Engelhard Mearl Pigment EP 97079    | 0.009<br>0.000022<br>0.00022<br>0.200    | 91.4           | fail        |      |
| Green with glass flake   | R203: Carbon Black Monarch 800<br>R883: C.I. Pigment Yellow 138<br>R36: Solvent Green 28 R0979: Engelhard Mearl Pigment EP 97079 | 0.0000133<br>0.00712<br>0.00329<br>0.200 | 90.9           | fail        |      |

TRM = amount of light transmitted through the substrate

BLER = pulses

fail = Unable to retrieve Volume Table of Contents (VTOC)

pass = booted

Electrical Test = did it play CD optical tester.

C.I. = Color Index

R0979 - commercially available from Engelhard, Peekskill, NY

R672 - commercially available from Clariant, Charlotte, NC

R65 - commercially available from Clariant, Charlotte, NC

R663 - commercially available from Clariant, Charlotte, NC

R73 - commercially available from Bayer, Pittsburgh, PA

R513 - commercially available from Ciba, Tarrytown, NY

R887 - commercially available from Bayer, Pittsburgh, PAR882 - commercially available from Clariant, Charlotte, NC

R7260 - commercially available from BASF, Mt. Olive, NJ

R666 - commercially available from Rose Color, New Ark, NJ

R203 commercially available from Cabot, Alpharetta, GA

R71 - commercially available from Bayer, Pittsburgh, PA

R883 - commercially available from BASF, Mt. Olive, NJ

R36 - commercially available from Bayer, Pittsburgh, PA

AM190 - commercially available from Flex Products, Santa Rosa, CA

AM080 - commercially available from Flex Products, Santa Rosa, CA

AM230 - commercially available from Flex Products, Santa Rosa, CA

[0048] An alternative technique for product differentiation, colored disks, however, have not been used for optical media substrates due to absorption of the laser light, which interferes with data readout. Furthermore, the use of optical effects, such as fluorescence, in optical media substrates has not been done because

5 fluorescence, in which light of a given color is absorbed and re-emitted at a different color, has not been tried because fluorescent emissions may interfere with the laser readout system. Other visual effects that may scatter an incident laser beam have similarly not been explored because, until recently, optical media consisted of 1-layer substrates, such as those in CD. Recently, the advent of DVD includes a second  
10 substrate layer which may be used for decorative purposes except in cases of multi-sided media. The use of inorganic fillers such as glass flake to produce visual effects may also alter rheological properties of a thermoplastic resin making it difficult to produce optical media substrates from such compositions.

[0049] Use of color or other visual effects in optical media substrates provides  
15 a way to differentiate brands of optical media. This differentiation can be used for increased appeal in the market, brand recognition, and can help avoid problems with unwanted duplication of data. Colored substrates can also provide an advantage of wavelength selectivity that cannot be obtained with colorless materials.

[0050] Data storage media substrates comprising visual effects have not previously been produced due to the significant adverse effect on rheology imparted by the visual effects. Previously, decorative labels would be glued to a surface of the substrate. In contrast, the substrates described herein can comprise the visual effects

5 as part of the substrate, i.e., a molded layer disposed on one side of the substrate.

Alternatively, the visual effects can be disposed between two substrates with reflective and data layers disposed between the visual effects and the substrate, optionally, adhesives can be used for bonding. These visual effects could be employed for numerous purposes including product differentiation, decoration, anti-piracy, and the

10 like.

[0051] While preferred embodiments have been shown and described, various modifications and substitutions may be made thereto without departing from the spirit and scope of the invention. Accordingly, it is to be understood that the present invention has been described by way of illustrations and not limitation.

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